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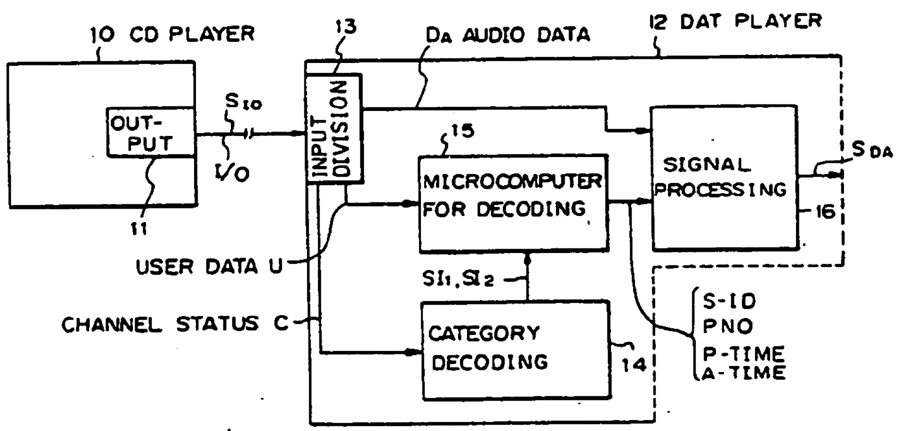
(54) **Apparatus for recording a digital signal.**

(57) A digital recording apparatus (12) for recording signals received in a digital interface format comprising a categoty code, specifying a device (10) on the transmission side, digital main data, and digital sub-data for control, includes a category decoder (14) for judging the category code of the received data. When the judged category code is different from the category code of the recording apparatus (12), a microprocessor (15) converts the digital sub-data into the necessary digital sub-code data for the recording apparatus (12) and the data are thereafter recorded.

Fig. 14



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APPARATUS FOR RECORDING A DIGITAL SIGNAL

This invention relates to apparatus for recording a digital signal.

In digital audio devices, such as compact disc CD players or digital audio tape recorder players (DATs), the read-out, recording and playback of a digital signal are performed on the basis of respective digital signal formats which are different for each device.

Therefore, if a digital signal is sent for recording from a device having one format to a device having a different format, the digital signal cannot be sent directly, and nor can the digital signal readily be satisfactorily recorded on the reception side.

To enable the transmission of a digital signal between different kinds of devices and the recording of the digital signal based on that transmission, a so-called digital interface format (I/O format) has been proposed.

In the case where the transmission of a digital signal is performed using the I/O format, a device on the reception side receives the digital signal while always confirming a category code specifying the kind of a device on the transmission side. If the kinds of device on the transmission and reception sides are the same, that is, when the category codes are the same, both the digital audio data and the digital sub-data (sub-code) are accepted and recorded on the device on the reception side. However, if the kinds of device are different and the category codes are different, the digital audio data is accepted and recorded but the digital sub-data (sub-code) is judged to be unsuitable for decoding, so that it cannot be accepted or recorded.

For this reason, when the category codes are diffrent, a sub-code such as a signal for detecting the beginning of a piece, for example, cannot be recorded, with the result that the audio data cannot be used effectively even if the audio data are recorded on the reception side.

According to the present invention there is provided an apparatus for recording a transmitted digital signal formatted according to a predetermined digital interface format which includes main data, digital sub-codes, such as a device category code, user data and channel status, wherein the recording apparatus is capable of recording digital main data and digital sub-code data, including a category code specifying the recording apparatus' device type, according to a predetermined format, the recording apparatus being characterized by:
means supplied with the transmitted digital signal for detecting from the digital sub-codes a category code indicating the type of device which transmitted the digital signal; and
means supplied with the transmitted digital signal for converting the transmitted digital sub-code data into corresponding sub-code data formatted according to the format of the recording apparatus when the detected category code is different from its own category code;
whereby the recording apparatus is enabled to record the received main digital data and the converted sub-code data onto a recording medium .

In an embodiment of this invention, a digital recording apparatus for recording signals received by means of a digital interface format composed of a category code, specifying a device on the transmission side, digital main data, and digital sub-data for control, includes means for judging the category code of the received data. When the judged category code is different from the category code of the recording apparatus, means is provided for converting the digital sub-data into the necessary digital sub-code data for the recording apparatus, and the data are thereafter recorded.

More particularly, a digital signal sent through a digital interface based on an I/O format from a digital device on the transmission side is divided into audio data D_A and sub-code (control signals) at an input dividing circuit on the reception side. The digital audio data D_A are supplied directly to a digital signal processing circuit, and the sub-code is further divided into user data U and a channel status C. The channel status C of the sub-code is supplied to a category decoding circuit, and the user data U is supplied to a microcomputer for decoding.

The category decoding circuit judges the kind of device on the transmission side on the basis of a category code Cc of the channel status C.

In the case where the devices on the transmission side is a different kind of digital device having a data format different from the reception side, a discrimination signal SI_1 is supplied to the microcomputer.

In response to this discrimination signal SI_1, the microcomputer develops various kinds of sub-code data, for instance, start ID (S-ID), a track (piece) number (PNO), a programme duration time (P-time), an absolute duration time for the whole recording (A-time), etc. based on user data U supplied from a digital input dividing circuit. The microcomputer then supplies the sub-code data obtained from the user data U to the digital signal processing circuit.

The digital signal processing circuit converts the audio data D_A and various kinds of sub-code data into the recording format of a DAT, which is a

recording device on the reception side and performs recording.

Here, when the category decoding circuit judges that the device on the transmission side is the same kind of device and has the same category code as the reception side, a discriminating signal SI_2 is supplied to the microcomputer.

In response to the discrimination signal SI_2, the microcomputer separates a start ID (S-ID), a sync (SYNC) and a shortening ID as sub-code data from the user data U. The microcomputer then supplies the sub-code data to the digital signal processing circuit.

The digital signal processing circuit converts the above-stated audio data D_A and sub-code data into a DAT recording format and performs recording.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figures 1 and 2 are schematic diagrams for use in explaining the data format of a CD;

Figure 3 is a diagram showing the relationship between the P and Q channels on a CD;

Figure 4 is a schematic diagram showing a bit arrangement of the Q channel shown in Figure 2 and a control bit format;

Figure 5 is an explanatory diagram showing the tape format of a DAT;

Figure 6 is a schematic diagram for explanation of a track format and a block format of a DAT;

Figure 7 is a schematic diagram explaining a sub-code ID of a DAT;

Figure 8 is an explanatory diagram for explaining a control ID of a DAT;

Figure 9 is a schematic diagram for explaining a data ID;

Figures 10 and 11 are schematic diagrams for explaining a sub-code ID and sub-code data of a DAT;

Figure 12 is a schematic diagram for explaining a digital audio interface format;

Figure 13 is a schematic diagram showing a format of a bit arrangement of a channel status shown in Figure 12;

Figure 14 is a block diagram showing an embodiment of digital recording apparatus to which the present invention is applied; and

Figures 15 to 17 are schematic diagrams for respectively explaining an example for converting a digital signal based on a sub-code of a CD into a digital audio interface format.

Description of the embodiment will be given in the following order:

(a) The format of a digital output signal of a CD.

(b) The format of a digital output signal of a DAT.

(c) The I/O format of a digital audio interface.

(d) The transmission and conversion of a digital output signal from a CD to a DAT.

(a) The format of a digital output signal of a CD.

In a CD, a digital signal (in this section called a digital output signal) is converted and recorded in a digital data format shown in Figures 1 and 2. This data format handles 588 bits as one frame, and a sync pattern FS of a particular pattern is added to the head of each frame. The 0-th to the 32-nd bit following the frame sync FS comprise an alternating pattern of direct-current-component suppressing bits RBs, of three bits each, followed by data bits DBs, each having fourteen bits.

The 0-th data bit DB is a sub-code C_{SUB} corresponding to digital sub-data and is employed for playback control of a CD. The 1-st to 12-th and 17-th to 28-th data bits DB are allotted to the audio data D_A as digital audio data, and the remaining 13-th to 16-th and 29-th to 23-nd data bits DBs are assigned to parity data for an error correction code. For each data bit DB, 8-bit data are converted into fourteen bits by a known eight to fourteen conversion process on recording.

The 98 frames of the above-mentioned digital data are called one block, and with this one block various kinds of processes are carried out.

Figure 2 shows a data format in which one block (98 frames) are arranged in the order shown by eliminating the direct-current-component suppression bits RB and forming each data bit DB with eight bits. As shown in Figure 2, a sub-code C_{SUB} of each frame is composed of one symbol (eight bits), and 98 symbols forms one sub-code frame. Sub-code areas of the frames 0 and 1 form a sub-code sync pattern that is a predetermined bit pattern. Also, each of the eight bits of the sub-code C_{SUB} are separately labelled P, Q, R, S, T, U, V and W, respectively, beginning from the side of the sync patterns FS.

The physical correspondance between the P and Q channels of the sub-code C_{SUB} and the CD is shown in Figure 3. A lead-in area starts at the inner diameter of the Cd at about 46 mm and ends at about 50 mm. After this is a programme area of up to a maximum of 116 mm followed by a lead-out area. Also, a TOC (table of contents) is in the sub-code Q channel of the lead-in portion.

The P channel indicates the beginning of the lead-in area, the lead-out area and each track (piece of music). The P channel is a flag for indicating a pause and music. The flag takes a low

level for music and a high level for a pause, and has a pulse signal with a period of 2 Hz in the lead-out area. As a result, by detecting and counting the P channel, designated music can be selected.

The Q channel can perform the same kind of control in a more complicated manner and the bit construction in the Q channel is shown in Figure 4.

In Figure 4, the presence or absence of audio emphasis, the presence or absence of prohibition of digital copying, and information indicative of either a CD-ROM for audio purposes or a CD-ROM for computer purposes are represented by a flag. Also, a track number PNO shows the piece numbers from 1 to 99. The track number PNO number OO means a lead-in track and AA means a lead-out track. It is possible to divide each track into 1 to 99 by an index number. Here, an index number 00 means a muting interval. Also, there are two kinds of time codes, that is, P-time of track number unit and absolute time or A-time as shown in Figure 3. The P-time of a track number unit is reset for each track, and the A-time starts at the beginning of a music programme and continues until the whole programme ends.

By supplying the information of the Q channel into a microcomputer provided in the disc reproduction unit, random selection of music such as immediate movement to the playback of other music during the course of music reproduction can be done.

Channels R to W (6-bit parallel data) disposed after the P and Q channels are employed as graphic data and used to display the poet, the composer of a piece recorded in a disc, its explanation, lyrics, etc. or to explain the piece verbally.

(b) The format of a digital output signal of a DAT.

As shown in Figure 5, all the data recorded on each of the oblique tracks 7A and 7B formed on a magnetic tape 1 having a width A is called a segment. Here, in Figure 5, $\pm\alpha$ indicates the head gap angle azimuth ($\alpha = 20^{\circ}$) and the azimuth angles are mutually opposite in the adjacent tracks 7A and 7B. Also, an arrow indicates the tape forwarding direction. Figure 6A shows a recording format of one segment.

When it is assumed that a unit amount of recording data is one block, data of 196 blocks (7500 μ sec) is contained in one segment. As can be seen from Figure 5, one frame is made up of two tracks 7A and 7B formed by the heads A and B. Each of the tracks 7A and 7B has a length corresponding to the rotation of each of the respective heads through an angle of 90° and is partitioned from its lower end (that is from right to left in the figure) into 5.051° of a margin area of eleven blocks, 0.918° of a two block preamble area for the PLL of the sub-code, 3.673° of an eight block first sub-code CS_1, 0.459° of a one block postamble area, 1.378° of a three block interblock gap area in which data is not recorded, 2.296° of a five block pilot signal for ATF tracking area, 1.378° of a three block interblock gap area, 0.918° of a two block preamble area for the PLL of data, 58.776° of a 128 block data area, 1.378° of a three block interblock gap area, 2.296° of a five block AFT signal area, 1.378° of a three block interblock gap area, 0.918° of a two block preamble area for the PLL of the sub-code, 3.673° of an eight block, second sub-code area CS_2, 0.459° of a one block postamble area, and 5.051° of an eleven block margin area. It should be noted that the scale of the respective areas in Figure 5 is not exact.

The PCM signal is composed of a two-channel stereo PCM signal consisting of L (left) and R (right) channels, and parity data of an error detection/correction code. In the case where the one segment shown in Figure 6A is recorded/reproduced by a magnetic head (not shown), audio data Le is recorded on the left half side of the PCM signal recording area and audio data Ro is recorded on the right half side. The audio data Le is made up of even numbered audio data of the L channel and parity data for that data, while the audio data Ro are composed of odd numbered audio data of the R channel and parity data for those data. The even number and the odd number are the ones counted from the beginning of an interleave block. Similarly, one segment of data is recorded on a track formed by the other magnetic head with the same structure as one track mentioned above. The purpose of recording audio data of the even number and the odd number of each channel on two adjacent tracks separately and recording audio data of the L channel and the R channel on the same track, is to prevent continuous data errors of the same channel due to drop-out, etc.

Figure 6B shows the data block structure of the PCM data signal. At the start of the block, an 8-bit (that is one symbol) block synchronization signal is added, and an 8-bit PCM-ID, W1, is then added. Next to the PCM-ID, a block address W2 is added. The processing of error correction and coding of a simple parity if performed with respect to the two symbols W1 and W2 of the PCM-ID and the block address. The resulting 8-bit parity is added next to the block address and following that is placed the PCM data with its parity.

The block address W2 is composed of seven bits, except for the most significant bit (MSB) as shown in Figure 6D. A value of 0 as the most significant bit indicates that this block is the PCM

data block.

The block address W2 of seven bits varies sequentially from (00) to (7F) (hexadecimal notation). The PCM-ID is defined so that the three least significant bits of a block address may be recorded at each of blocks (000) (010) (100) (110). An optional code of the PCM-ID can be recorded in each block address having less significant bits (001) (011) (101) (111) of the block addresses. ID1 to ID8, each having two bits, and a frame address of four bits are contained in the PCM-ID. In the ID1 to ID7, respective identification information is defined. For example, the ID1 is a format ID for identifying whether it is for audio use or other use, the ID2 identifies pre-emphasis ON/OFF and the characteristic of the pre-emphasis, and the ID3 identifies a sampling frequency. The number of channels, the bit number of quantization, the track width, and permission for or inhibition of digital copying are identified by the ID4, ID5, ID6 and ID7, respectively. Also, the ID8 is a code for constructing a pack, and a pack is composed of 32 ID8s. The ID1 to ID7 and the frame address are regarded as the same data in the segment of interleave pair. Rewriting (after-recording) cannot be carried out for the PCM-ID differently from the sub-code ID recorded in the sub-codes 1 and 2.

Figure 6C shows the data block structure of the sub-code C_s (for example CS_1) as digital sub-data. It has a data structure similar to the above-mentioned PCM block. As shown in Figure 6E, when the most significant bit of the symbol W2 of the sub-code block is set to 1, this indicates that the block is a sub-code block. The four least significant bits of the symbol W2 are regarded as a block address, and eight bits of the symbol W1 and three bits, except for the MSB and the block address of the symbol W2, are treated as a sub-code ID. The error correction processing and coding of a simple parity is done with regard to the two symbols (W1 and W2) of the sub-code block so as to add an 8-bit parity.

The sub-code IDs take different data depending on whether there is an even numbered block address (LSB of the block address is 0) or odd numbered block address (LSB of the block address is 1). Namely, as shown in Figure 7, the sub-code ID of a block whose block address has the least significant bit 0 is made up of a control ID and data ID, each of which is composed of four bits. The sub-code ID of a block whose block address has the least significant bit 1 is composed of PNO ID(2) and PNO ID(3). A sub-code forming a word W2 contains a 4-bit format ID in the case of a block whose block address has the least significant bit 0, while it contains the PNO ID(1) in the the case of a block whose block address has the last significant bit 1.

A programme number, a lead-in area, a lead-out area, etc. are represented by three of the PNO ID(1) to PNO ID(3). A control ID designating a playback method, a time code, etc. are included in the sub-code ID. The sub-code data has been subjected to error-correction-code processing by Reed-Solomon code in a manner similar to the PCM data. It is to be noted that the sub-code ID can be rewritten differently from the above-mentioned PCM-ID. The above-described control ID represents control information composed of 4-bit data as shown in Figure 8, and each bit is set for a priority ID, a start ID (S-ID), a shortening ID, a table of contents ID (TOC-ID) from the MSB side in that order. The priority ID, the S-ID, the shortening ID and the TOC-ID indicate the presence or absence of after-recording of a piece number, the start of the piece and separation, fast forwarding until the next S-ID, and the presence or absence of TOC recording, respectively. Here, the start ID (S-ID) is a signal indicating the start of a programme, and is recorded for nine seconds (normal mode) from the start of a piece. At the time of playback, the start detection of the piece is executed by searching for this signal. Also, in the case of 1 as the priority ID, a priority if given to a piece number specified at the PNO-ID.

The data ID and the format ID are defined as shown in Figure 9. In the case of 0000 as the data ID, the sub-code data contains a pack, and the format ID indicates an applied area of the pack. With respect to data ID other than all 0s, no special definition is given.

The sub-code block shown in Figure 6C has a structure more specifically shown in Figure 10. Figure 11 shows that two adjacent sub-code blocks are represented as one and that the sub-code data has a pack construction.

Each pack has a data structure consisting of 64 bits (eight symbols) as shown in Figure 11. In Figure 11, the recording direction is the longitudinal direction, and word names are attached from PC1 to PC8 for every eight bits in the horizontal direction. The first four bits of the word PC1 are treated as one item, and with this item, the contents of the pack are indicated as follows:

Item (0000):
means that all of PC1 and PC8 are 0s.

Item (0001):
means that data of the pack represent the programme time.

Item (0010):
means that data of the pack represent the absolute time of a tape.

Item (0011):
means that data of the pack represent the duration of one recording.

Item (0100):

means that data of the pack represent TOC data.
Item (0101):
means that data of the pack represent year, month, date, a day of the week, time.
Item (0110):
means that data of the pack indicate a catalogue number.
Item (0111):
means that data of the pack indicate ISRC (the international-standard-recording code).
Item (1111):
means that data of the pack are defined by a maker of a software tape.

Items other than the above-mentioned ones are not defined.

Also, the word PC8 of the pack is made as a simple parity code of the words PC1 to PC7.

As shown in Figure 10, a maximum of seven of said packs (pack 1 to pack 7) and a C1 parity are placed sequentially in two blocks. The number of packs is indicated by the format ID. For example, in the case of the format ID (000), the number of packs is zero; in the case of the format ID (001), there is only pack 1; in the case of format ID (111), there are packs 1 to 7.

(c) The I/O format of a digital audio interface.

Figure 12 shows a format of a digital audio interface (I/O format). As shown in Figure 12A, it is assumed that a sampling period (1/Fs) is one frame to give a basic unit. Each digital output signal of the left (L) channel and the right (R) channel in this one frame is transmitted in the order from LSB (the least significant bit) to the left channel and the right channel, respectively. Data corresponding to each channel is called a sub-frame, and Figure 12B shows one sub-frame. A sub-frame is composed of 32 bits, and two sub-frames (both of the left and right channels) make one frame.

As shown in Figure 12B, a preamble (four bits) for a synchronization for head detection and identification of a sub-frame is added to the head of the sub-frame. This allows for the identification of the left and right channels and judgement for whether it is the head of a block. The four next bits are auxiliary bits (AUX) and following that are twenty bits of audio data D_A bits (audio sample) disposed as digital main data. After the audio data D_A, control signals, each having one bit, are disposed as digital sub-data represented by V, U, C and P. The auxiliary bits, audio data D_A and control signals are biphase-mark modulated.

V is a validity flag to indicate whether data are correct. The flag shows that data of a sub-frame are valid (reliable) if it is 0, while it shows that the data are invalid (unreliable) if it is 1. For example, if both of the left and right channels are sent and the V of only the right channel is 1, a digital device on the reception side reads only the left channel. U is user data, C is a channel status, and P is a parity bit. An even parity is used for the parity bit, for example, and error detection of the auxiliary bits, audio data D_A and the control signals is carried out.

As shown in Figure 13, the channel status C is defined by a data format in which 192 bits (one word) contained in the respective sub-frames are gathered. Here, the channel status forms one block with 192 frames and this one block forms channel statuses of the left and right channels (two words).

By this one word (192 bits) of channel status, the kind of device on the transmission side, the sampling frequency, etc. are indicated. Specifically, the first bit (bit 0) of one word identifies home use (private use) and broadcasting use. Assuming that the home use has a mode II and the broadcasting use has a mode I, different formats are allotted to them, respectively. The presence or absence of emphasis and prohibition of digital copying (bit 2) are then defined by control bits 1 to 5. Therefore, the presence or absence of the prohibition of copying is judged by examining the control bit 2. The designation of a device on the transmission side is performed by a category code Cc formed of bit 8 to bit 15, and a sampling frequency is indicated by bit 24 to bit 27. The accuracy of the sampling frequency is indicated using the two bits bit 28 and bit 29.

The error of the sampling frequency is defined by bits 31 and 32. This is because there is a problem that a device on the reception side cannot follow the sampling, depending on the degree of dispersion of the sampling frequencies and because of copying with this problem. Here, the sub-code (control signals V, U, C and P) are dealt with the unit of a block (192 frames).

(d) The transmission and conversion of a digital output signal from a CD to a DAT.

As shown in Figure 14, assuming that a digital audio device on the transmission side is a CD player and a digital recording device on the reception side is a DAT, an example in which a digital output signal transmitted from the CD player is data-converted and recorded with the DAT will be explained.

As shown in Figure 14, a digital input dividing circuit 13, a category decoding circuit 14, a microcomputer 15 for decoding and a digital signal processing circuit 16 are provided in a DAT 12. In a CD player 10, a digital-output-forming circuit 11 is provided. The digital-output-forming circuit 11 is for converting a CD output signal, having a format

shown in Figure 1, into an I/O format shown in Figure 12, and supplying its converted signal. The digital-output-forming circuit 11 in the CD player 10 and the input dividing circuit 13 in the DAT 12 are connected by an interface cable which could be an optical transmission or a coaxial cable, for example.

The input dividing circuit 13 divides the digital output signals S_{10} supplied from the CD player 10 on the basis of an I/O format into audio data D_A and sub-code data composed of the control signals V, U, C, P. The audio data D_A is supplied to the digital signal processing circuit 16. Also, the channel status C is supplied to the category decoding circuit 14, and the user data U is supplied to the microcomputer 15.

The category decoding circuit 14 judges that the kind of a digital device on the transmission side is a CD player 10 on the basis of the category code Cc of the channel status C from the input dividing circuit 13. The category decoding circuit 14 supplies a discrimination signal SI_1 to the microcomputer 15 when the kinds of the devices on the transmission and reception sides are different.

The microcomputer 15 develops the user supplied sub-code data such as the start ID (S-ID), the track number, that is the piece number (PNO), the time of the piece (P-Time), the absolute time (A-Time), etc., from the input dividing circuit 13, and supplies the data to a digital signal processing circuit 16 with a predetermined timing.

The digital signal processing circuit 16 takes in the audio data D_A supplied from the input dividing circuit 13 and the sub-code data fed from the microcomputer 15 according to the predetermined timing and reformats them into the DAT recording format shown in Figure 6A for output and recording by a recording section (not shown) of the DAT 12.

The following are examples of how the DAT 12 performs data conversion and recording of a digital output signal S_{IO} formatted according to the I/O format from the transmission side:

1. Formation of the digital output signal S_{IO} based on the I/O format on the CD player 10 side.

2. Data conversion processing and conversion into a DAT format of the digital output signal S_{IO} in the DAT 12.

3. Processing and conversion into the DAT format of a digital output signal in a device on the reception side when the CD player 10 is changed into a DAT.

1. Formation of the digital output signal S_{IO} based on an I/O format in the CD player 10.

First, the audio data D_A of the CD shown in Figure 1 is transferred into the slot of the audio data D_A of an I/O format shown in Figure 12B for each sample. In this case, in the CD format, there are twelve samples of audio data D_A (six samples x two channels) per frame as shown in Figure 2. However, since only two samples of the audio data D_A per frame can be transmitted in the I/O format as shown in Figure 13B, six frames (6 x 2 = 12 sub-frames) in the I/O format are needed to transmit the audio data D_A of one frame of CD.

As a result, one frame of the CD sub-code similarly corresponds to six frames of the I/O format, and the slots of six preambles and twelve bits (six frames x two sub-frames x one bit/sub-frame = twelve bits) for each of the control signal V, U, C and P are provided. Namely, the control signals V, U, C and P per one frame of CD are each twelve bits. Consequently, the control signals V, U, C and P form a data format of 98 frames (corresponding to one block of CD) in the longitudinal direction, twelve bits in the lateral direction (corresponding to one frame of CD) as shown in Figure 15A.

Hereafter, how each sub-code is added to this data format is shown.

A flag for validity or invalidity is added to the control signal V (validity) for every sample. The control signal U (user data) forms one sub-code block of 98 frames. The sub-code sync word is a minimum of sixteen 0 bits. In the case of Figure 15A, 24 0 bits in the 0-th and 1-st frames are the sub-code sync word. A start bit (1), a sub-code (Qi to Wi of the i-th frame of CD and dummy bits (that is 0s) are inserted, respectively, at the first bit of the head, the second to the eight bits, and the ninth to the twelfth bits are shown in Figure 15A. A distance WL (word length) between the start bits is varied between eight bits and sixteen bits by changing the number of dummy bits as shown in Figure 15B. Data of the format shown in Figure 13 is encoded depending on a predetermined code contained in the control signal C (channel status). A parity bit for even parity is added to the control signal P (parity). In this way, the CD audio data D_A and sub-code C_{SUB} are converted into an I/O format, respectively to be the digital output signal S_{IO} and produced serially to the DAT 12 from the CD player 10.

2. Data conversion processing and conversion into a DAT format of the digital output signal S_{IO} in the DAT player 12.

The input dividing circuit 13 divides the re-

ceived digital signal S_{IO} into digital audio data D_A and sub-code (control signals).

The audio data D_A is supplied directly to the digital signal processing circuit 16, and the sub-code if further divided into the user data U and the channel status C. The channel status C in the sub-code is supplied to the category decoding circuit 14, and the user data U is supplied to the micro-computer 15.

The above-mentioned category decoding circuit 14 judges the kind of device on the transmission side based on the category code Cc of the channel status C. In this example, the device on the transmission side is the CD player 10, and a discrimination signal SI_1 indicating that it is a different kind of device from the DAT 12 is supplied to the micrcomputer 15.

The microcomputer 15 develops various kinds of DAT sub-code data, for example, a start ID (S-ID), a track number, that is piece number (PNO), a progress time P-Time, an absolute time A-Time, etc. as shown in Figures 4 and 16 based on the user data U to the digital signal processing circuit 16 according to a predetermined timing.

The microcomputer 15 then supplies various kinds of data obtained from the user data U to the digital signal processing circuit 16 according to the predetermined timing.

The digital signal processing circuit 16 converts the above-mentioned audio data D_A and various kinds of sub-code data into a recording format shown in Figure 6A to form a digital output signal S_{DA} and supplies and records it onto a recording section (not shown) of the DAT 12.

In the recording, parity is added to the audio data D_A and recorded in a data area of a PCM block.

In addition, with respect to the sub-code data of a DATA, the start ID (S-ID) is continuously recorded in the bit of the start ID provided in the sub-code ID (control ID shown in Figure 8) for nine seconds from the head of a piece as shown in Figure 16. Also, a track number PNO is recorded in the PNO-ID provided in the sub-code ID.

The programme time (P-Time) and the absolute time (A-Time), etc. are respectively recorded on packs shown in Figure 10 provided in the DAT sub-code data area.

In such a manner, the sub-code data of the digital output signal S_{IO} is converted into data necessary for the DAT 12 on the reception side and processed and then made into the digital output signal S_{DA} together with the audio D_A to be recorded according to the DAT format.

3. Processing and conversion into the DAT format of a digital output signal when the device 10 is changed to a DAT.

When the device 10 on the transmission side is changed from a CD player to a DAT, the user data U becomes 1 in each timing shown in Figure 17. A sync SYNC, a start ID and a shortening ID are identified by this timing of 1. It is judged that the device 10 on the transmission side is the same kind of digital device having the same category code as the device 12 on the reception side. A discrimination signal SI_2 indicative of that effect is supplied to the microcomputer 15.

In response to the above-mentioned discrimination signal SI_2, the microcomputer 15 develops sub-code data from the start ID (S-ID), the sync SYNC and the shortening ID shown in figures 17A to C among the user data U. The user data U becomes 1 in response to the sync SYNC at a predetermined timing (each word L_o of every 30 msec as shown in Figure 17A), and the start ID is supplied to the digital signal processing circuit 16. This start ID has been set to 1 for nine seconds from the head of a programme (a piece) as shown in Figure 16C for searching for the piece, and the start ID is detected by the DAT 12 to perform the head detection of the piece.

Further, when the microcomputer 15 detects the shortening ID inserted in the programme as shown in Figures 16 and 17 from the control signal U (user data), it supplies the shortening ID to the digital signal processing circuit 16. The digital signal processing circuit 16 converts the audio data D_A and sub-code data into a DAT recording format for supply and recording by a recording section (not shown) of the DAT 12. Namely the audio data D_A is record in a data area of the PCM block and the DAT format, and with respect to the sub-code data the start ID (S-ID) and the shortening ID are recorded, respectively, at each bit of the corresponding start ID and shortening ID of the control ID shown in Figure 9. Also, the sync SYNC is recorded at the head of each programme for synchronization to perform the head detection.

Here, although digital audio devices such as the CD player 10 and the DAT 12 are exemplified for explanation in this embodiment, the invention is applicable to digital recorder/player devices generally.

Since an embodiment detects a category code based on a signal transmitted by a device on the transmission side through a digital interface and when the detected category code is different from its own category code, digital sub-data are converted into its own necessary data and stored. For this reason, digital sub-data of a digital signal transmitted from the transmission side through the digi-

tal interface can be converted into necessary data on the reception side. This operation occurs even if the transmitting digital device has a data format different from that of the receiving device. As a result, a digital signal can be recorded as a whole in better form on the reception side.

Consequently, since digital, control sub-data (sub-code) can be recorded, in addition to digital audio main data, differently from previously proposed systems, such operations as head detection of pieces and skipping can be done. As a result, the digital audio data recorded on the reception side can be fully used.

Claims

1. An apparatus (12) for recording a transmitted digital signal formatted according to a predetermined digital interface format which includes main data, digital sub-codes, such as a device category code, user data and channel status, wherein the recording apparatus (12) is capable of recording digital main data and digital sub-code data, including a category code specifying the recording apparatus' device type, according to a predetermined format, the recording apparatus (12) being characterized by:
means (14) supplied with the transmitted digital signal for detecting from the digital sub-codes a category code indicating the type of device (10) which transmitted the digital signal; and
means (15) supplied with the transmitted digital signal for converting the transmitted digital sub-code data into corresponding sub-code data formatted according to the format of the recording apparatus (12) when the detected category code is different from its own category code;
whereby the recording apparatus (12) is enabled to record the received main digital data and the converted sub-code data onto a recording medium (1).

2. Apparatus (12) according to Claim 1 further comprising means (13) supplied with the transmitted digital signal for separating the main data, user data and channel status from the digital interface format, and wherein said detecting means (14) detects the category code from the separated channel status data.

3. Apparatus (12) according to Claim 1 comprising a digital audio tape recorder (12) and wherein said converting means (15) generates subcodes for the digital audio tape recorder (12) such as a start ID and a track number based on user data.

Fig. 1

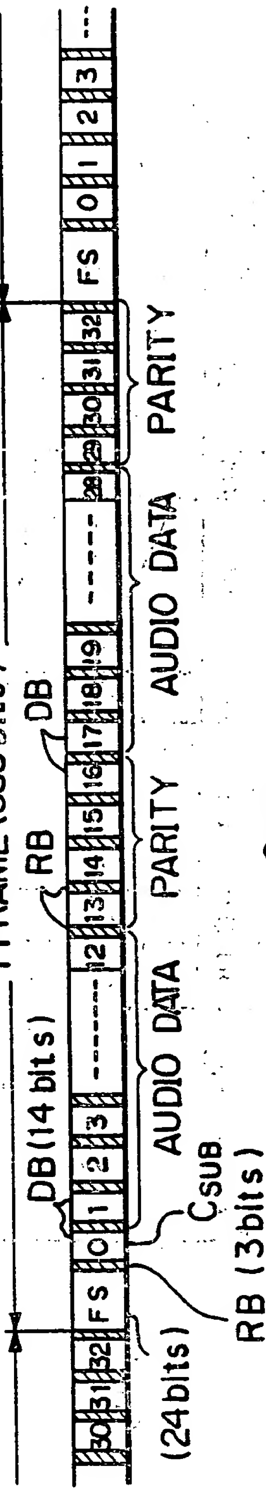

1 FRAME (588 bits)
DB (14 bits)
RB
DB
FS
(24 bits)
RB (3 bits)
CSUB
AUDIO DATA
PARITY
AUDIO DATA
PARITY

Fig. 2

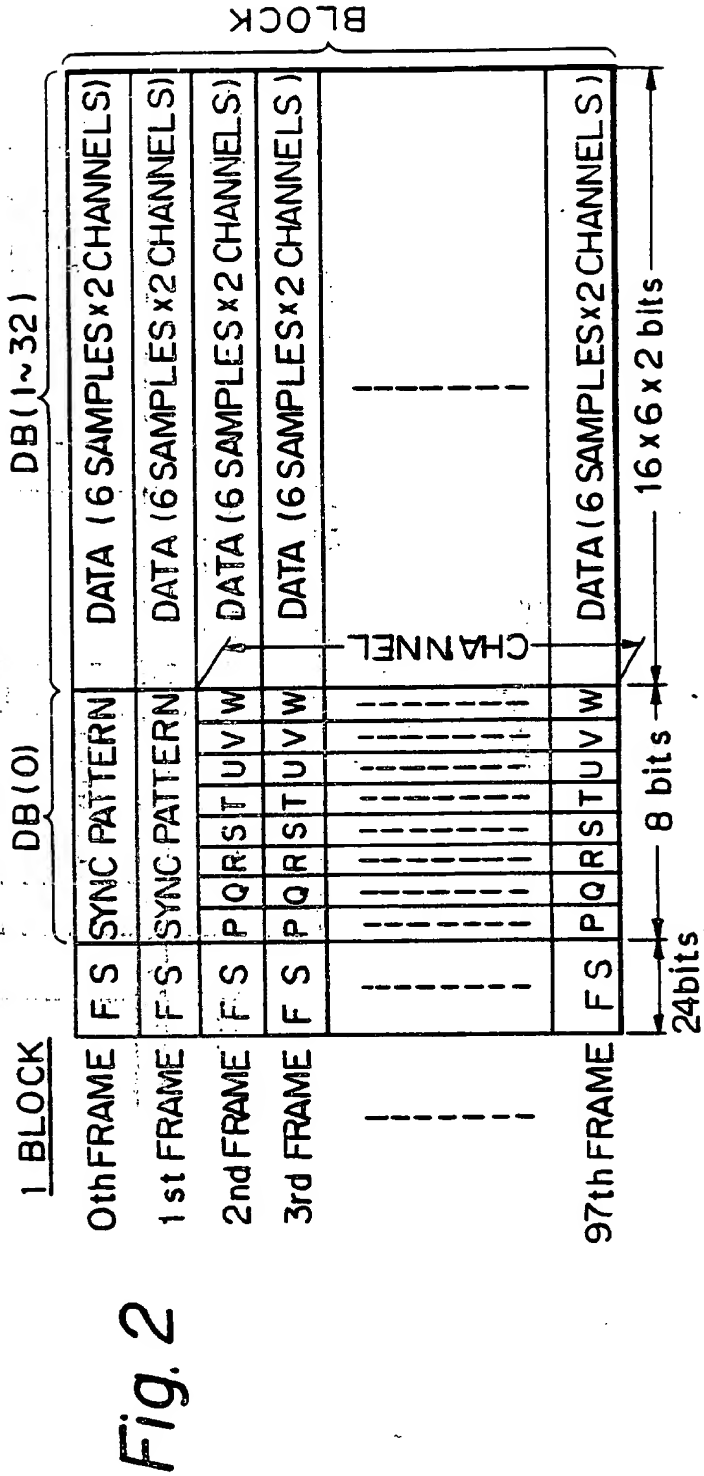
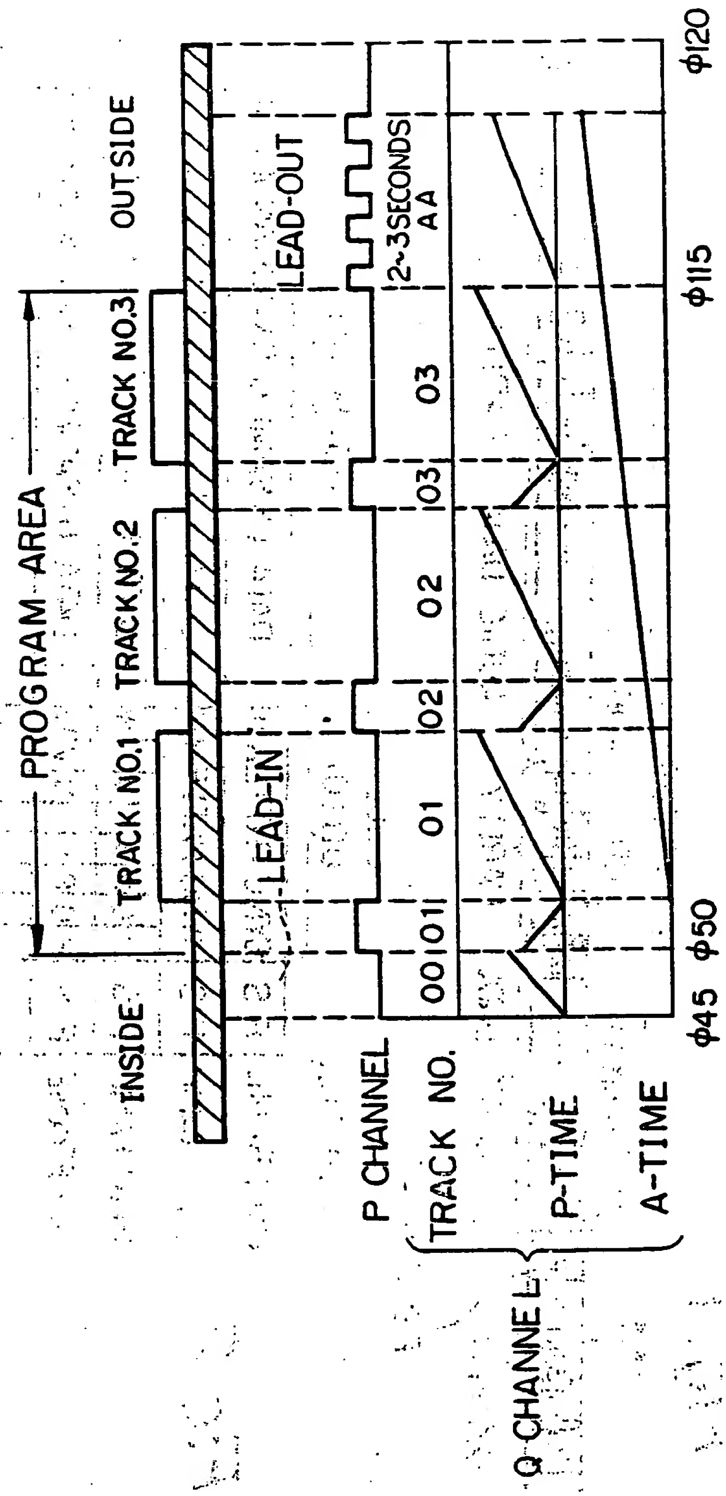

BLOCK
1 BLOCK
DB(0)
CSUB
DB(1~32)
0th FRAME
1st FRAME
2nd FRAME
3rd FRAME
97th FRAME
FS
SYNC PATTERN
P Q R S T U V W
DATA (6 SAMPLES x 2 CHANNELS)
CHANNEL
24bits
8 bits
16 x 6 x 2 bits

Fig. 3



PROGRAM AREA
INSIDE
OUTSIDE
TRACK NO.1
TRACK NO.2
TRACK NO.3
LEAD-IN
LEAD-OUT
2~3SECONDS
AA
00
01
01
01
02
02
03
03
φ45
φ50
φ115
φ120
P CHANNEL
TRACK NO.
P-TIME
A-TIME
Q CHANNEL

Fig. 4

Start bit	Q1 Q2 Q3 Q4	Q5 Q6 Q7 Q8	Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16	End bit
	FLAG	ADDRESS 0 0 0 1	TRACK NUMBER PNO	
Q17	INDEX		MINUTES P-TIME	Q32
Q33	SECONDS P-TIME		FRAME NUMBER OF SUBCODE	Q48
Q49	(UNDECIDED) 0 0 0 0	0 0 0 0	ABSOLUTE TIME A-TIME	Q64
Q65	ABSOLUTE TIME A-TIME		ABSOLUTE NUMBER OF FRAME	Q80
Q81	ERROR DETECTION CODE (CRC CODE)			Q96

FLAG:

0 0 X 0 AUDIO USE
0 0 X 1 EMPHASIS ON/OFF
0 1 X 0 DIGITAL DATA RECORDING
X X 0 X COPY PROHIBITION
X X 1 X YES/NO

X: DONT CARE

Fig. 5

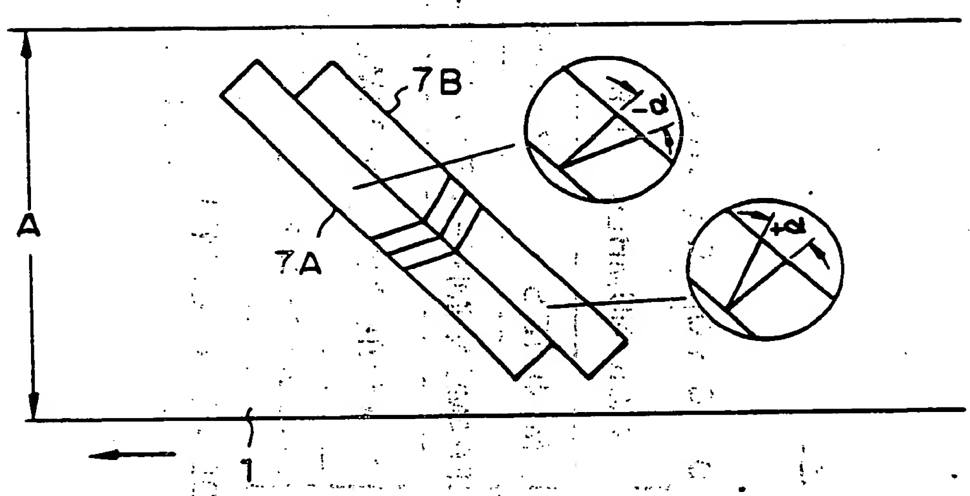


Fig. 7

W1		W2		
SUB CODE ID			SUBCODE ID	BLOCK ADDRESS
CONTROL ID	DATA ID	1	FORMAT ID	X X X 0
PNO ID (2)	PNO ID (3)	1	PNO ID (1)	X X X 1

MSB LSB MSB LSB

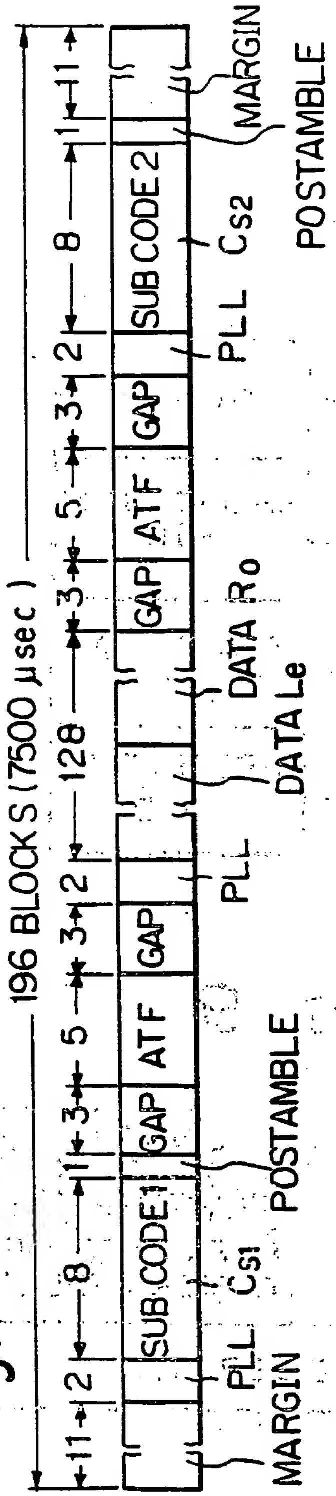


Fig. 6A

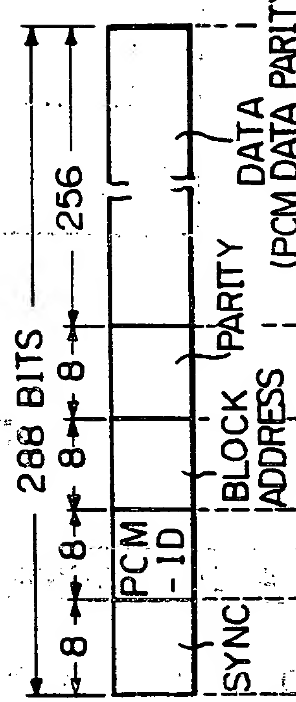


Fig. 6B

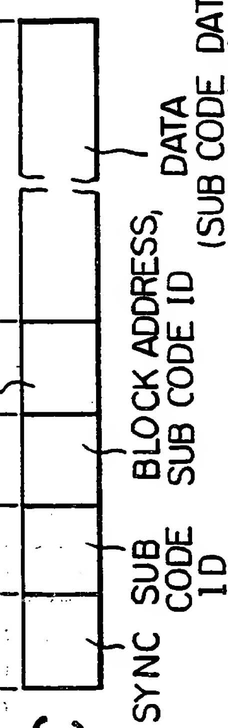


Fig. 6C

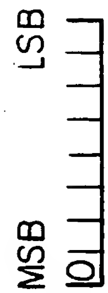


Fig. 6D

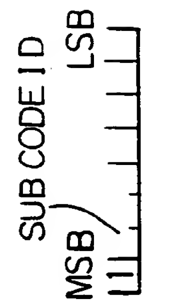


Fig. 6E

Fig. 8

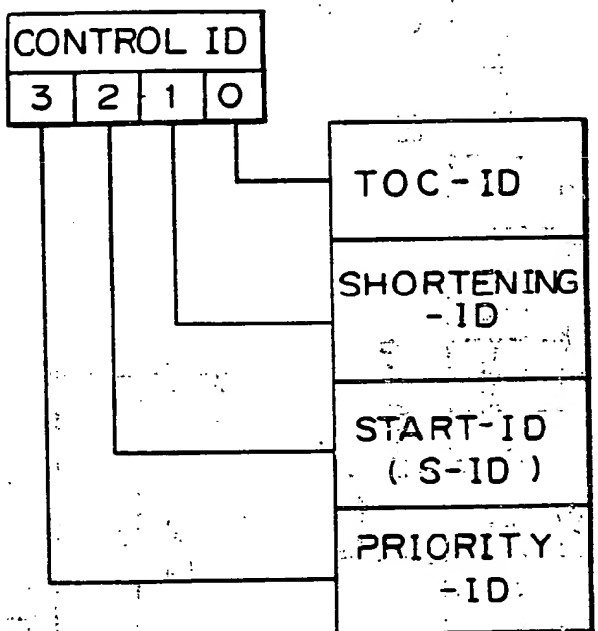


Fig. 9

	DATA ID	FORMAT ID	CONNOTATION
	0 0 0 0	X X X	SUBCODE DATA CONTAINS A PACK. FORMAT ID INDICATES A PACK APPLIED AREA
	0 0 0 1 ~ 0 1 1 1	RESERVED	

Fig. 10

SYNC	CTL ID	0 0 0 0	1	F ID	XXX0	PARITY	PACK 1	PACK 3	PACK 5	PACK 7
SYNC	PNO 2	PNO 3	1	PNO1	XXX1	PARITY	PACK 2	PACK 4	PACK 6	C 1

Fig. 11

WORD NAME	MSB	LSB
P C 1	ITEM	1 2 3 4
P C 2	5 6 - - -	
P C 3		
P C 4		
P C 5		
P C 6		
P C 7		- - - 52
P C 8	PARITY	

Fig. 12A

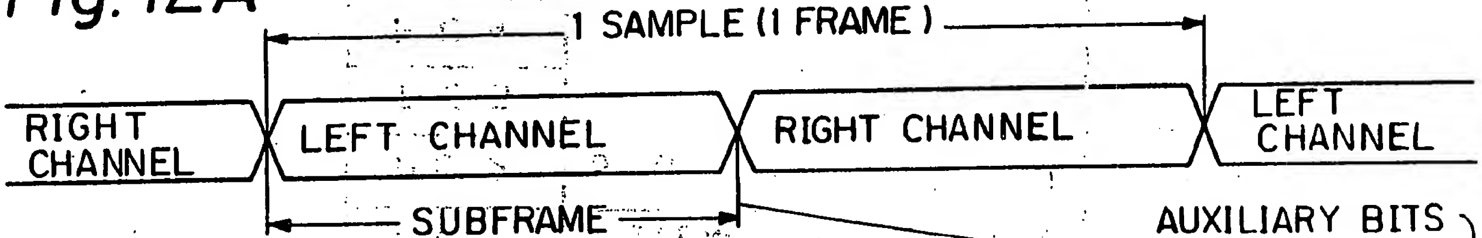


Fig. 12B

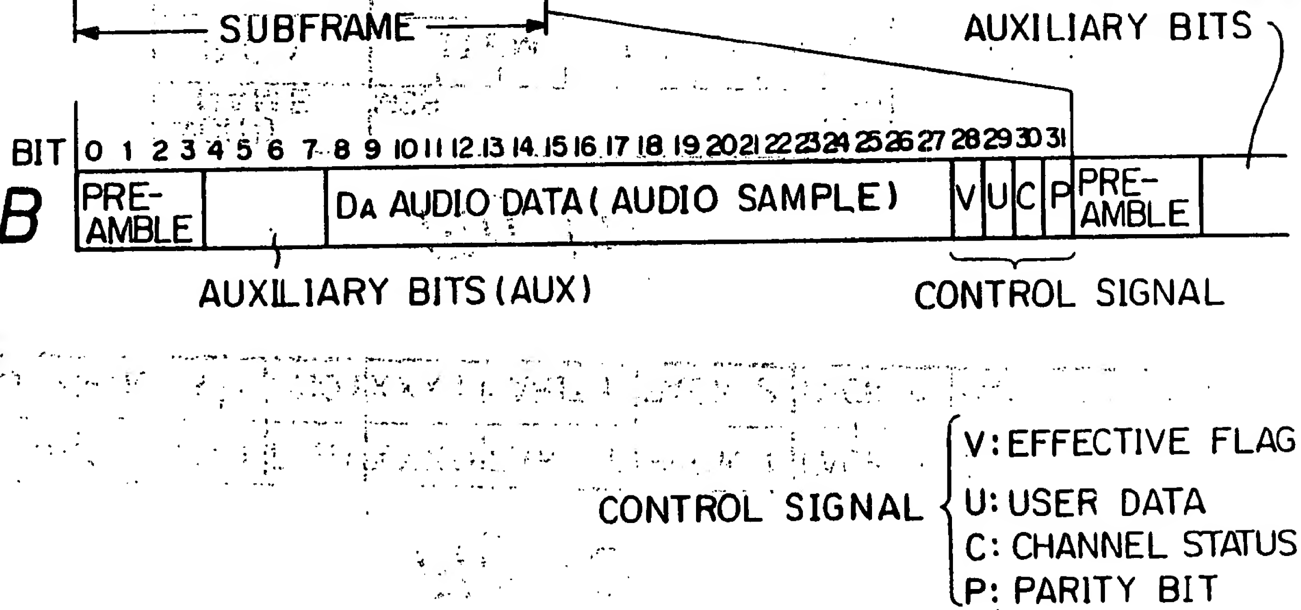


Fig.13

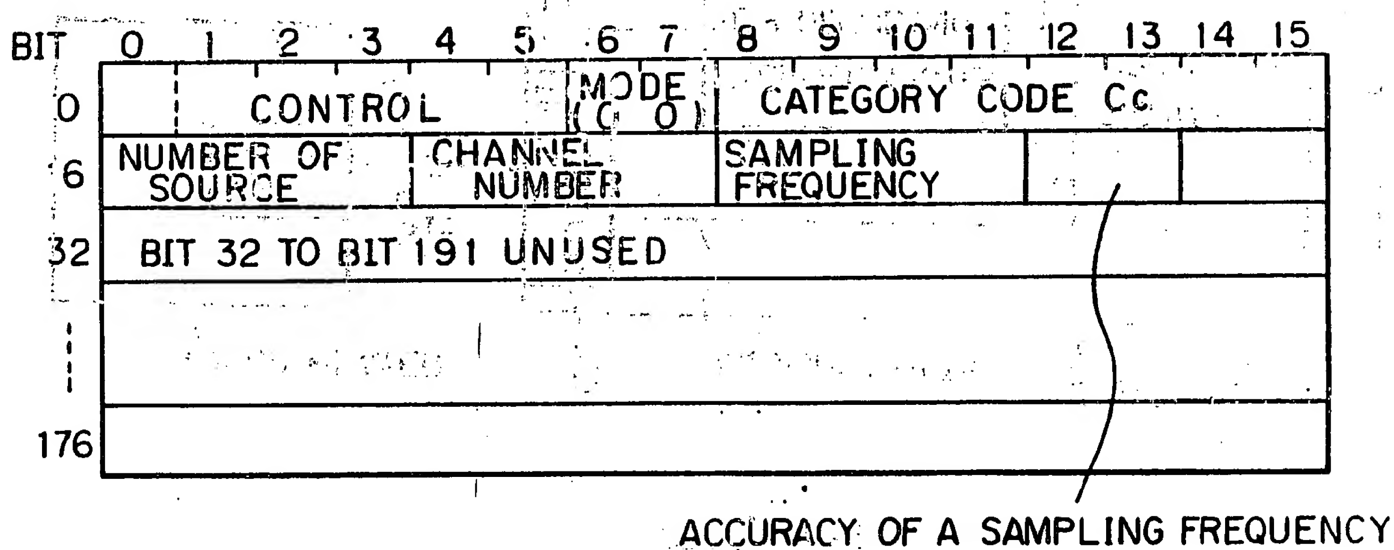

BIT
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
0
6
32
176
CONTROL
MODE (C O)
CATEGORY CODE Cc
NUMBER OF SOURCE
CHANNEL NUMBER
SAMPLING FREQUENCY
BIT 32 TO BIT 191 UNUSED
ACCURACY OF A SAMPLING FREQUENCY

Fig. 14

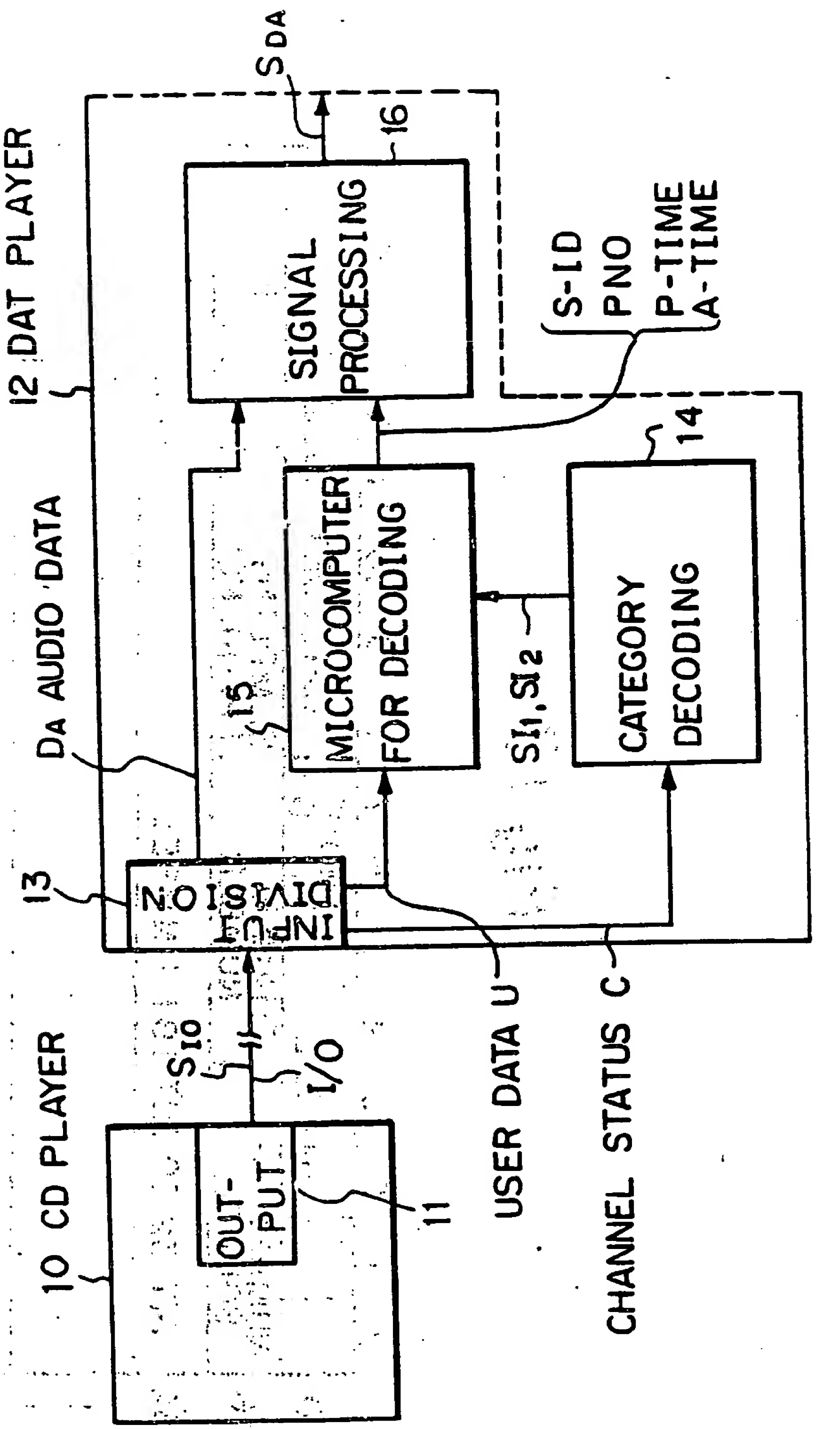

10 CD PLAYER
OUT-PUT
11
S_{IO}
I/O
USER DATA U
CHANNEL STATUS C
13
INPUT DIVISION
12 DAT PLAYER
D_A AUDIO DATA
15
MICROCOMPUTER FOR DECODING
SI_1, SI_2
14
CATEGORY DECODING
SIGNAL PROCESSING
16
S_{DA}
S-ID
PNO
P-TIME
A-TIME

Fig. 15A

SUBCODE SYNC WORD

	1	2	3	4	5	6	7	8	9	10	11	12	
	0	0	0	0	0	0	0	0	0	0	0	0	0th FRAME
13	0	0	0	0	0	0	0	0	0	0	0	0	FIRST FRAME
25	1	Q1	R1	S1	T1	U1	V1	W1	0	0	0	0	SECOND FRAME
37	1	Q2	R2	S2	T2	U2	V2	W2	0	0	0	0	THIRD FRAME
⋮	·	·	·	·	·	·	·	·	·	·	·	·	⋮
1165	1	Q96	R96	S96	T96	U96	V96	W96	0	0	0	0	97th FRAME

Fig. 15B

	0	0	0	0	0	0	0	0	0	0	0	0	SUBCODE SYNC WORD
13	0	0	0	0	0	0	0	0	0	0	0	0	
25	1	Q1	R1	S1	T1	U1	V1	W1	1	Q2	R2	S2	MIN. LENGTH WORD (= 8)
37	T2	U2	V2	W2	0	0	0	0	0	0	0	0	
49	1	Q3	R3	S3	T3	U3	V3	W3	0	0	0	0	MAX. LENGTH WORD (=16)
61	0	0	0	0	1	Q4	R4	S4	T4	U4	V4	W4	
73	1	Q5	R5	S5	T5	U5	V5	W5	0	0	0	0	
85	·	·	·	·	·	·	·	·	·	·	·	·	

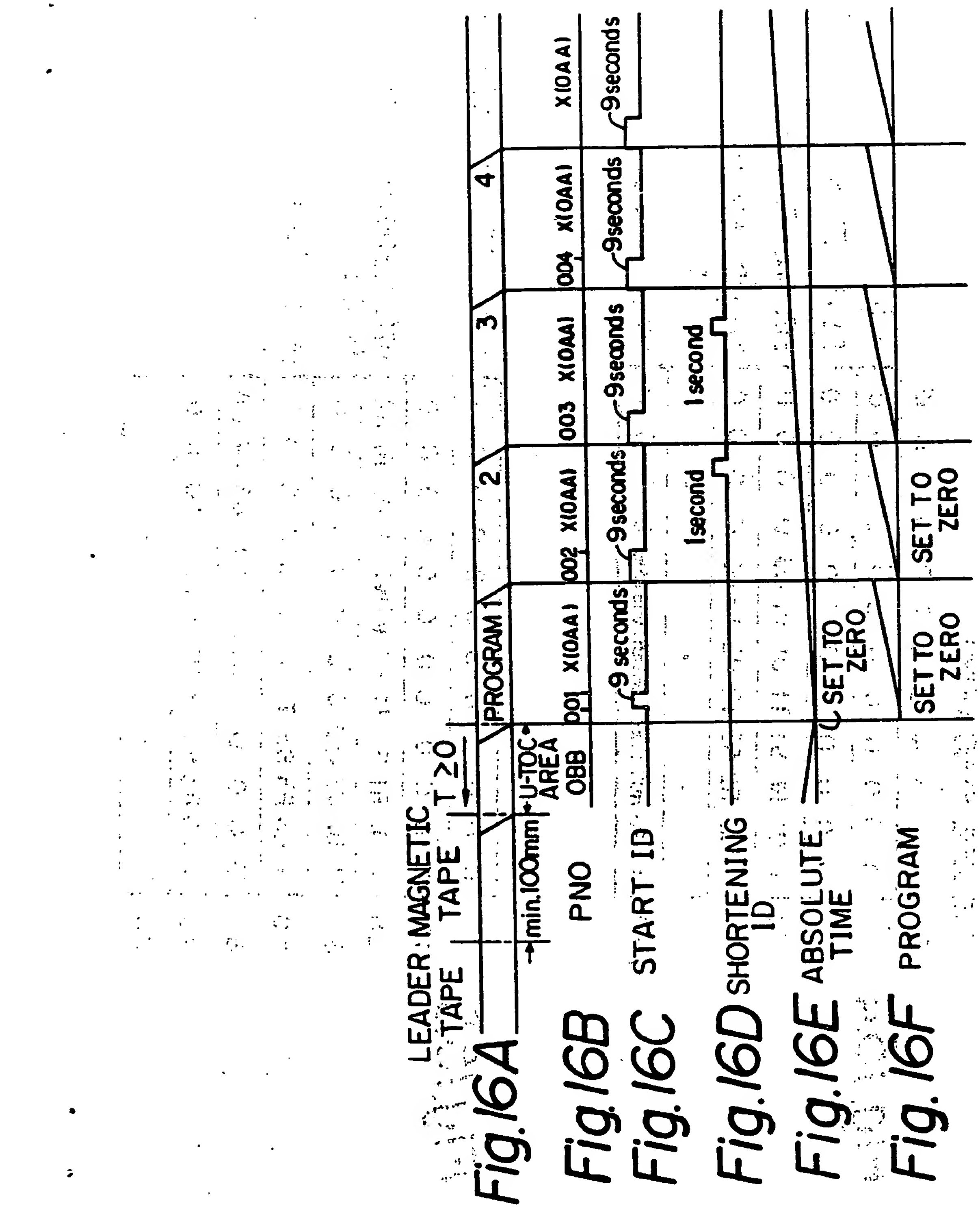


Fig.16A
LEADER TAPE
MAGNETIC TAPE
T ≥ 0
min.100mm
U-TOC AREA
PROGRAM 1
2
3
4
Fig.16B
PNO
0BB
001
X(0AA)
002
X(0AA)
003
X(0AA)
004
X(0AA)
X(0AA)
Fig.16C
START ID
9 seconds
9seconds
9seconds
9seconds
9seconds
Fig.16D
SHORTENING ID
1second
1second
Fig.16E
ABSOLUTE TIME
SET TO ZERO
Fig.16F
PROGRAM
SET TO ZERO
SET TO ZERO

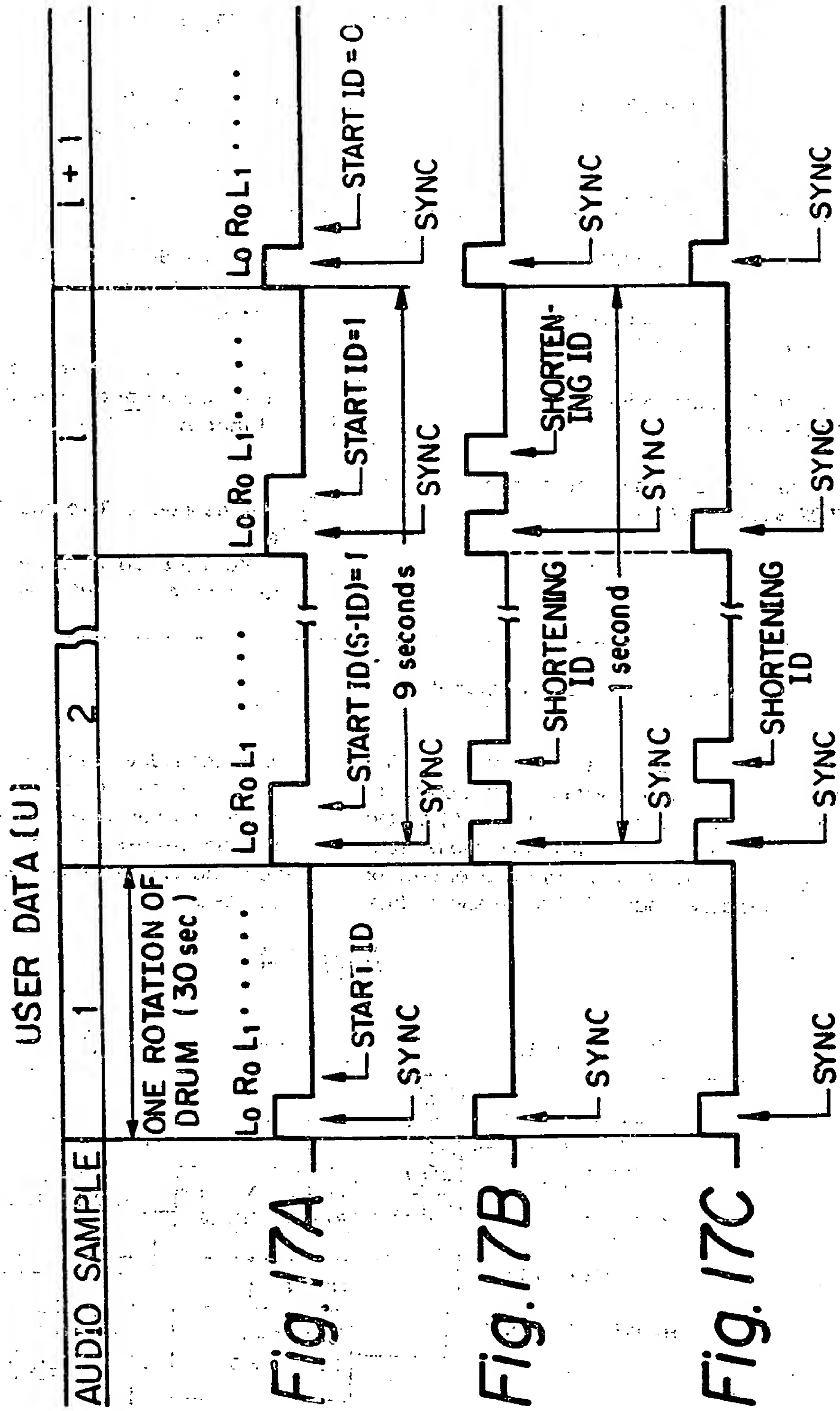


Fig. 17A

Fig. 17B

Fig. 17C

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(11) Publication number: **0 308 148 A3**

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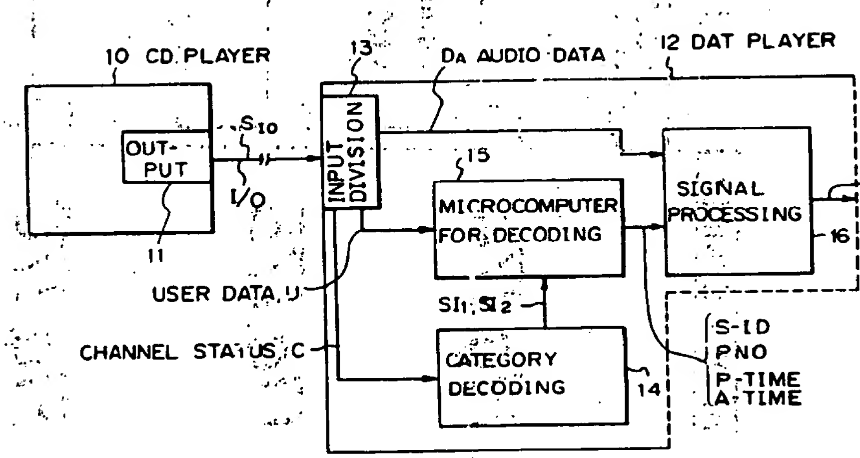
(54) **Apparatus for recording a digital signal.**

(57) A digital recording apparatus (12) for recording signals received in a digital interface format comprising a categoty code, specifying a device (10) on the transmission side, digital main data, and digital sub-data for control, includes a category decoder (14) for judging the category code of the received data. When the judged category code is different from the category code of the recording apparatus (12), a microprocessor (15) converts the digital sub-data into the necessary digital sub-code data for the recording apparatus (12) and the data are thereafter recorded.

Fig. 14



EP 0 308 148 A3

BNSDOCID: <EP___0308148A3_I_>

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 8376

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	JP-A -62 107473 (HITACHI LTD.,) 18 May 1987 & PATENT ABSTRACTS OF JAPAN vol. 11, no. 319 (P-627) 17 October 1987 * see Abstract of JP-A-62 107473 *	1-3	G11B20/10 G11B20/12 G11B27/30 //G11B27/02
A	JP-A-62 209777 (SONY CORP.) 14 September 1987 * see & EP-A 0237020 , page 11,line 32-page 21, line 7 and figure 5 *	1-3	
A	JP-A-62 192077 (PIONEER ELECTRONIC CORP.) 22 August 1987, & PATENT ABSTRACTS OF JAPAN vol. 12, no.46 (P-665) (2893) 12 February 1988 * see Abstract of JP-A-62 192077 *	1,3	
A	GB-A-2 175 731 (SHARP K.K.) * the whole document *	1,3	
A	EP-A-0 134 817 (WILLI STUDER ET AL.) * the whole document *	1	**TECHNICAL FIELDS SEARCHED (Int. Cl.4)**
E	PATENT ABSTRACTS OF JAPAN vol. 13, no. 285 (E-780)29 June 1989 & JP-A-1 068 148 (SONY CORP.) 14 March 1989	1-3	G11B
L	(priority) * abstract *		
P,A	ELEKTOR ELECTRONICS, vol. 14, no. 157, June 1988, CANTERBURY GB pages 14 - 18; 'PHILIPS-SONY DIGITAL AUDIO INTERFACE' * the whole document *	1-3	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 MAY 1992	F. J. DAALMANS

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